MAKRONUTRIEN

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MACRONUTRIENTS

- Macronutrients are needed in larger quantities (in gram range).
- They normally include water, carbohydrates, fat and protein.
- Macronutrients (except water) are also called energy-providing nutrients.
- Energy is measured in calories and is essential for the body to grow, repair and develop new tissues, conduct nerve impulses and regulate life process.

MACRONUTRIENTS

1. Carbohydrates
2. Lipids
3. Protein

Macronutrients

- Provide energy
- Maintain structure
- Provide functional integrity

CARBOHYDRATES

- Required for energy and provide body's main source of energy (4 calories per gram);
- The major part of stored food in the body for later use of energy and exist in three form: sugar, starch and fiber.
- The brain works entirely on glucose alone.
- When in excess, it is stored in the liver as Glycogen. Carbohydrates are also important for fat oxidation and can also be converted into protein.

FATS

- Used in making steroids and hormones and serve as solvents for hormones and fat soluble vitamins.
- Fats have the highest caloric content and provide the largest amount of energy when burnt.
- When measured by a calorimeter, fats provide about 9 calories per gram of fat, making them twice as energy-rich than protein and carbohydrates.
- Extra fat is stored in adipose tissue and is burnt when the body has run out of carbohydrates.

PROTEINS

- Provide amino acids and make up most of the cell structure including the cell membrane.
- They are the last to be used of all macronutrients.
- In cases of extreme starvation: the muscles in the body, that are made up of proteins, are used to provide energy.
- This is called muscle wasting.
- As for carbohydrates, proteins also provide 4 calories per gram.

WATER

- Makes up a large part of our body weight and is the main component of our body fluids.
- The body needs more water every day than any other nutrient and we replenish it through foods and liquids we eat and drink
- Water serves as a carrier, distributing nutrients to cells and removing wastes through urine
- It is also a compulsory agent in the regulation of body temperature and ionic balance of the blood
- Water is completely essential for the body’s metabolism and is also required for lubricant and shock absorber

ATOMS AND MOLECULES

- Atoms
  - Total of 103 elements have been identified
  - The human body is made up of elements
    - Nitrogen – 3%
    - Hydrogen – 10%
    - Carbon – 18%
    - Oxygen – 65%
- Molecules
  - Created when two or more atoms are united
  - Chemical bonds hold the molecules together

CARBON — A VERSATILE ELEMENT

- Carbon is a component of all nutrients, except for water and minerals.
- Carbon bonds with hydrogen, oxygen, and nitrogen to form carbohydrates, lipids, and proteins.
- Vitamins are also carbon based.

CARBOHYDRATES

- Monosaccharides
  - One sugar molecule
- Disaccharides
  - Two sugar molecules bonded together
- Oligosaccharides
  - Combination of 3-9 monosaccharides
- Polysaccharides
  - Combination of 10 to thousands of sugar molecules in chains
  - Usually glucose

MONOSACCHARIDES

- Glucose – $C_6H_{12}O_6$
- Fructose – $C_6H_{12}O_6$
- Galactose – $C_6H_{12}O_6$
  - Each has a unique atomic arrangement, giving them different biochemical characteristics.

GLUCOSE

- Glucose is also called dextrose or blood sugar.
  - Used directly by the cell for energy
  - Stored as glycogen in the muscles and liver for later use
  - Converted to fat and stored for energy

FRUCTOSE AND GALACTOSE

- Fructose is also called levulose or fruit sugar.
  - The liver converts fructose to glucose.
- Galactose forms milk sugar called lactose.
  - The body converts galactose to glucose for energy metabolism.

DISACCHARIDES

- Combining two monosaccharide molecules forms a disaccharide.
- Each disaccharide includes glucose as a principle component.
  - Sucrose = Glucose + Fructose
  - Lactose = Glucose + Galactose
  - Maltose = Glucose + Glucose

POLYSACCHARIDES

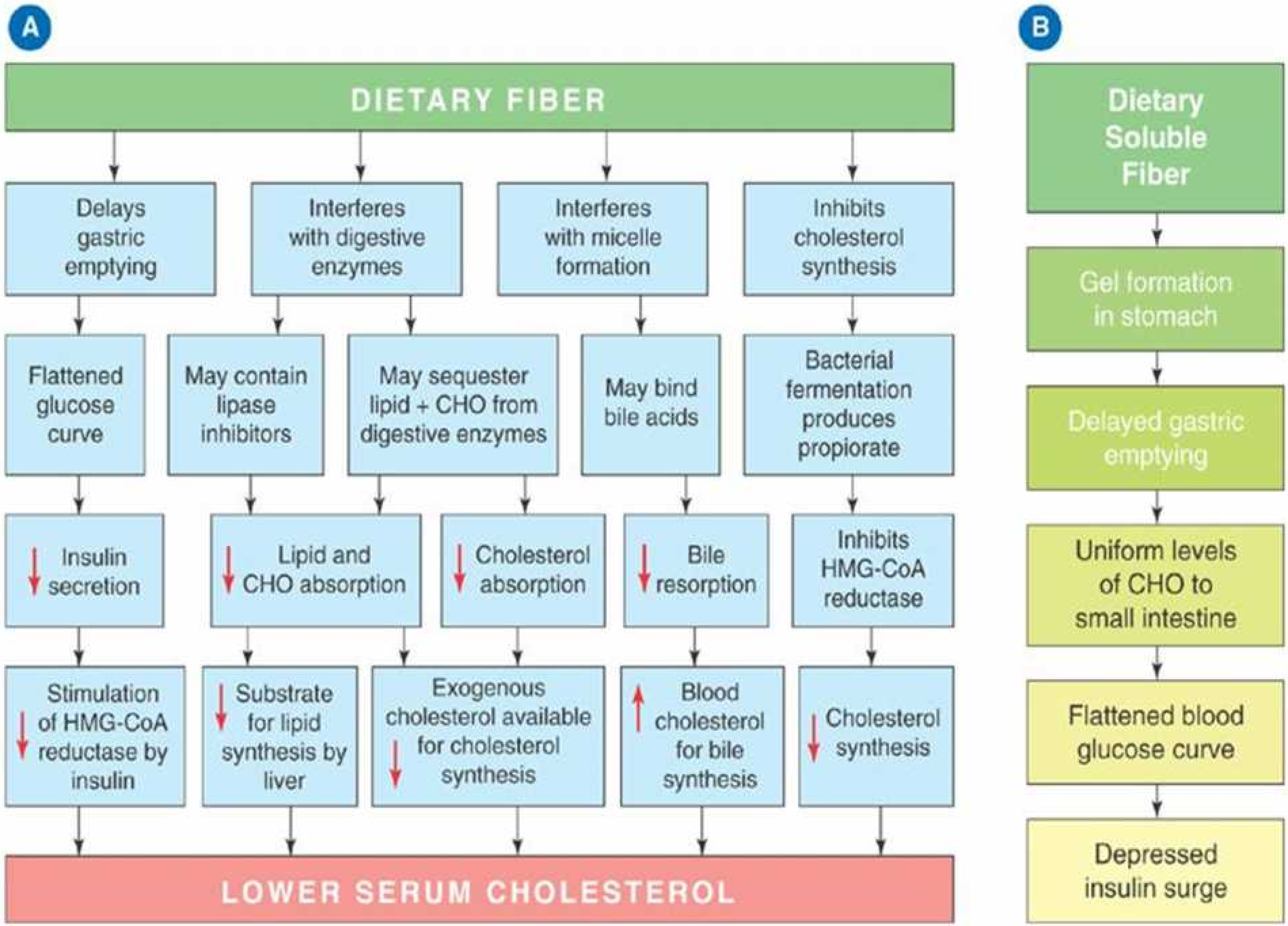
- Polysaccharides are classified into plant and animal categories.
- Glycosidic bonds link monosaccharides together to form polysaccharides.

PLANT POLYSACCHARIDES

- Starch and fiber are two common forms of plant polysaccharides.
- Starch
  - Plant starch accounts for approximately 50% of the total carbohydrate intake of Americans.
  - The term “complex carbohydrate” commonly refers to dietary starch.

POLYSACCHARIDES

- Fiber
  - Fibrous materials resist hydrolysis by human digestive enzymes.
  - Fibers differ widely in physical and chemical characteristics.
    - Water-soluble gums and pectin
    - Water-insoluble cellulose, hemicellulose, and lignin

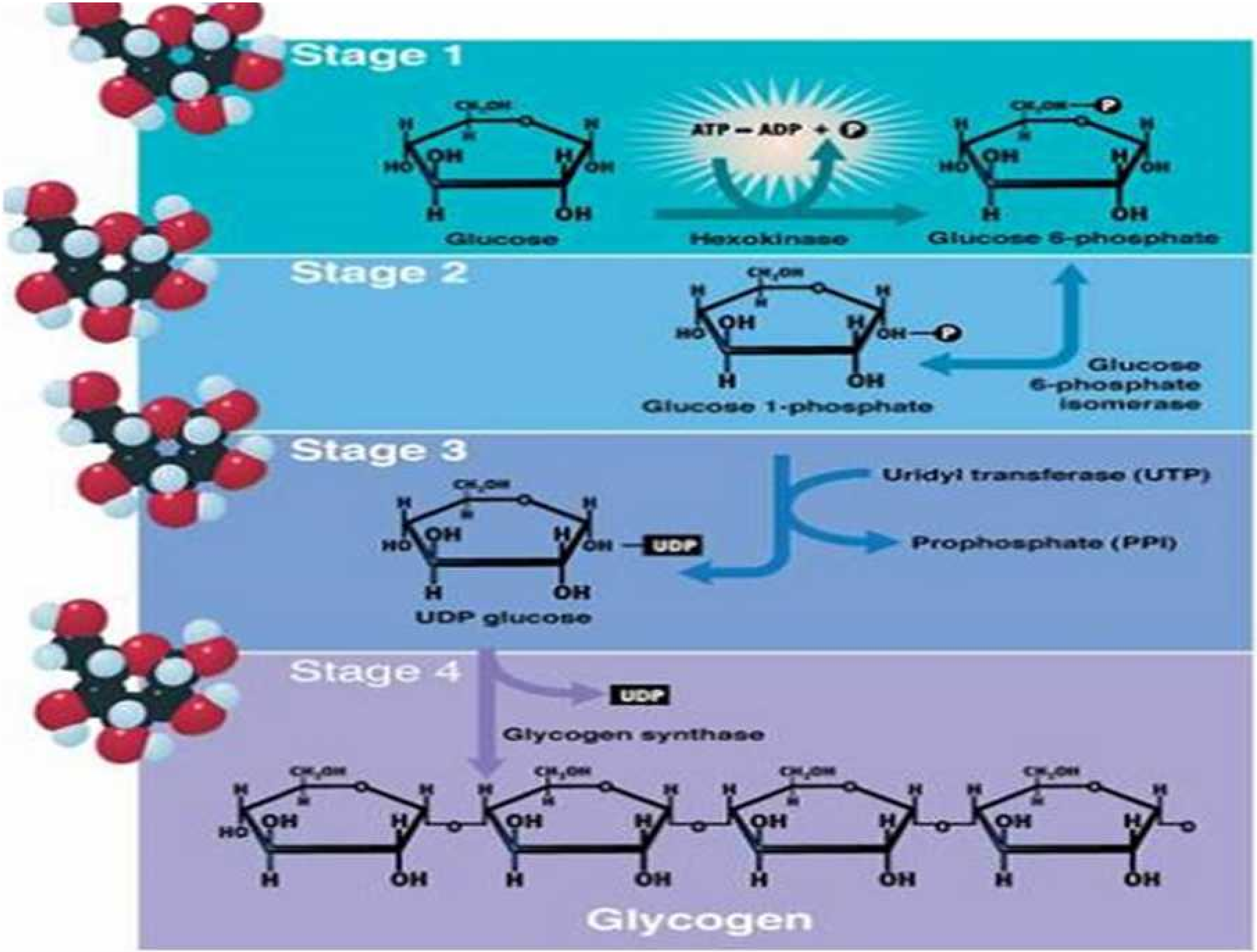

A
DIETARY FIBER
Delays gastric emptying
Interferes with digestive enzymes
Interferes with micelle formation
Inhibits cholesterol synthesis
Flattened glucose curve
May contain lipase inhibitors
May sequester lipid + CHO from digestive enzymes
May bind bile acids
Bacterial fermentation produces propiorate
Insulin secretion
Lipid and CHO absorption
Cholesterol absorption
Bile resorption
Inhibits HMG-CoA reductase
Stimulation of HMG-CoA reductase by insulin
Substrate for lipid synthesis by liver
Exogenous cholesterol available for cholesterol synthesis
Blood cholesterol for bile synthesis
Cholesterol synthesis
LOWER SERUM CHOLESTEROL
B
Dietary Soluble Fiber
Gel formation in stomach
Delayed gastric emptying
Uniform levels of CHO to small intestine
Flattened blood glucose curve
Depressed insulin surge

ROLES OF FIBER

- Retains considerable water and thus gives “bulk” to the food residues in the intestines
- Binds or dilutes harmful chemicals
- Shortens transit time for food residues (and possibly carcinogenic materials) to pass through the digestive tract

ANIMAL POLYSACCHARIDES

- Glycogen is the storage polysaccharide found in mammalian muscle and liver.
- Glycogen is synthesized from glucose during glucogenesis.
- Glycogenolysis is the reconversion process; it provides a rapid extramuscular glucose supply.


Stage 1
ATP — ADP + P
Glucose
Hexokinase
Glucose 6-phosphate
Stage 2
Glucose 1-phosphate
Glucose
6-phosphate
isomerase
Stage 3
Uridyl transferase (UTP)
Prophosphate (PPI)
UDP
UDP glucose
Stage 4
UDP
Glycogen synthase
Glycogen

GLYCOGEN DYNAMICS

- Hormones help to regulate blood sugar levels.
- Insulin enables peripheral tissues to take up glucose.
- Glucagon stimulates liver glycogenolysis and gluconeogenesis to raise blood glucose concentration.

RECOMMENDED INTAKE

- Regular physical activity: 60% of total intake (400-600 grams)
- During intense training: 70% of total intake
- Typical American diet: 40-50% of total intake

ROLES OF CARBOHYDRATE

- Energy source
- Adequate carbohydrate intake preserves tissue proteins.
- Metabolic primer/prevents ketosis
- Fuel for the central nervous system (CNS) and red blood cells

HYPOGLYCEMIA

- Low blood levels of sugar
- Can result in weakness, hunger, and dizziness
- Impairs exercise performance
- Prolonged and profound hypoglycemia can result in the loss of consciousness and in brain damage.

THE NATURE OF LIPIDS

- Lipid is a general term for a heterogeneous group of compounds.
  - Oils, fats, waxes, and related compounds
- Lipid molecules contain the same structural elements as carbohydrate.

THREE MAIN GROUPS OF LIPIDS

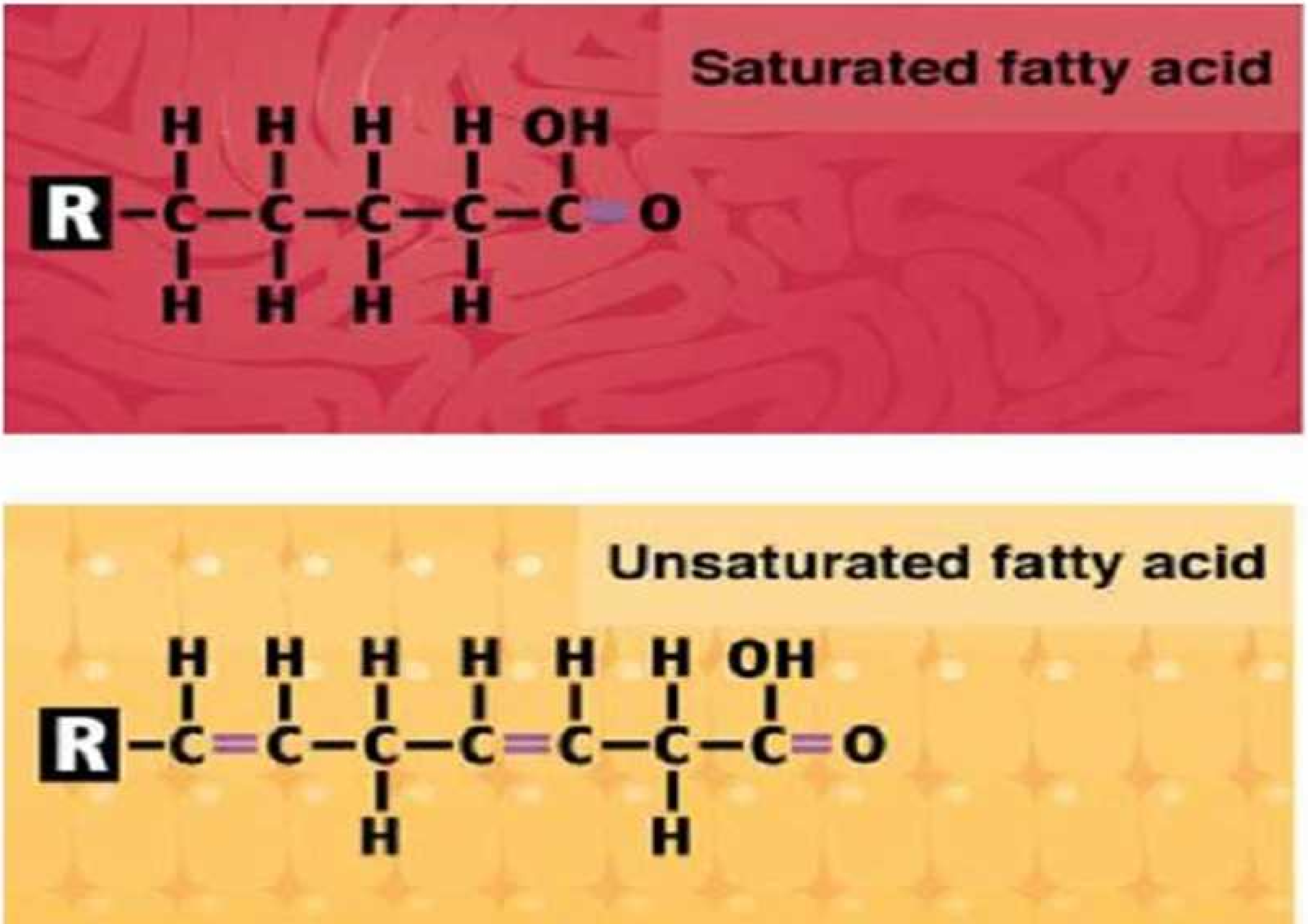
- Simple lipids
  - Neutral fats – consist primarily of triacylglycerols
  - Major storage form of fat in adipose cells
- Compound lipids
  - Consist of a triacylglycerol molecule combined with other chemicals
- Derived lipids
  - Formed from simple and compound lipids
  - Contain hydrocarbon rings (i.e., cholesterol)

TRIGLYCERIDES

- Glycerol – a 3-carbon alcohol molecule
- Three clusters of carbon-chained atoms, termed fatty acids, attach to the glycerol molecule to form a triglyceride.
- Most dietary and storage fat is in this form.

FATTY ACIDS

- Saturated fatty acids contain only single covalent bonds between carbon atoms; all of the remaining bonds attach to hydrogen.
- Unsaturated fatty acids contain one or more double bonds along the main carbon chain.
  - Monounsaturated fatty acid contains one double bond.
  - Polyunsaturated fatty acid contains two or more double bonds.


Saturated fatty acid
H H H H OH
R –C–C–C–C–C=O
H H H H
Unsaturated fatty acid
H H H H H H OH
R –C=C–C–C=C–C–C=O
H H

OILS

- Oils exist as liquid and contain unsaturated fatty acids.
- Omega-3 family of fatty acids
  - These oils are characterized by the presence of a double bond three carbons from the “n” end of the molecule.

LIPIDS IN THE DIET

- Typical daily lipid intake: 66% animal lipids, 34% vegetable lipids
- Average saturated fat consumption: 15% of total calories
- Saturated fat increases the risk for coronary heart disease.

ESSENTIAL FATTY ACIDS

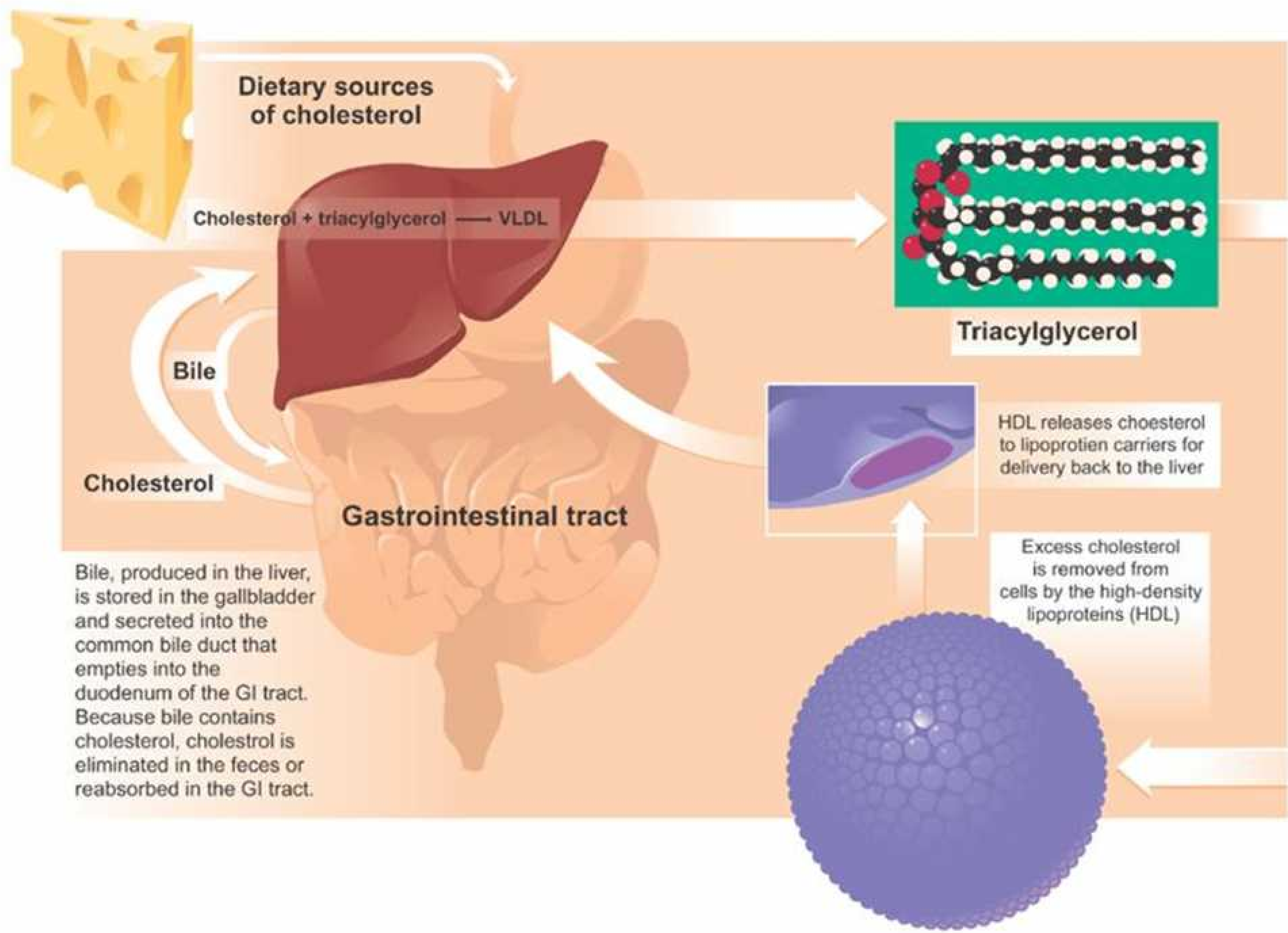
- Fatty acids that the body cannot synthesize
  - Linoleic acid: omega-6 polyunsaturated fatty acid
  - Alpha-linolenic acid and related omega-3 fatty acids
  - Oleic acid: major omega-9 fatty acid
- Fish oils have an antiarrhythmic effect on myocardial tissue.
- All fats contain a mix of each fatty acid type, although different fatty acids predominate in certain lipid sources.

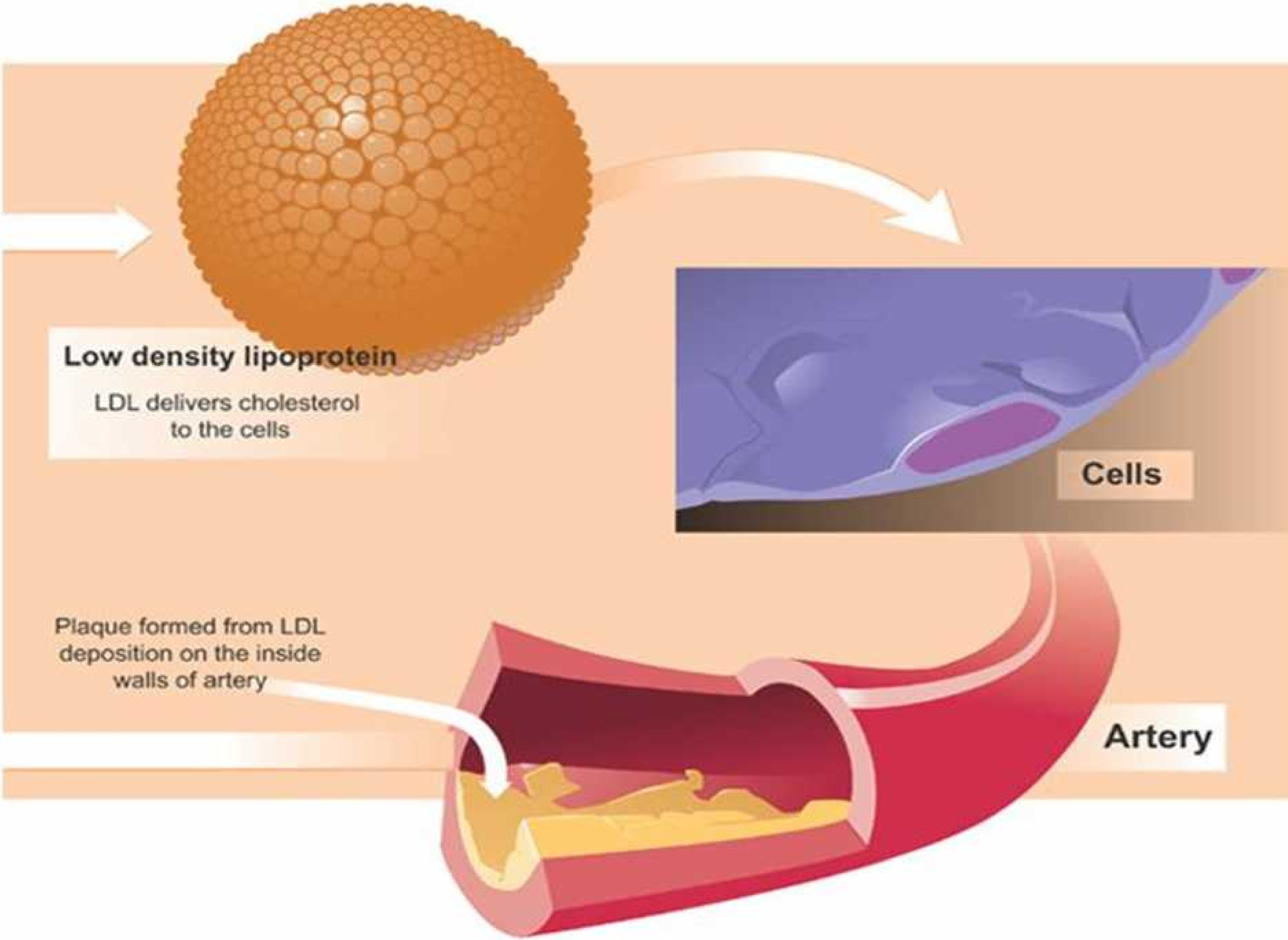
COMPOUND LIPIDS

- Triacylglycerol molecules combined with other chemicals
  - Phospholipids: one or more fatty acids, a phosphorus-containing group, and a nitrogenous base
- Glycolipids: fatty acid bound with carbohydrate and nitrogen
- Lipoproteins: proteins joined with triacylglycerols or phospholipids

CHOLESTEROL AND LIPOPROTEINS

- High-density lipoprotein (HDL) contains more protein and less lipid and cholesterol than the other lipoproteins.
- Very low-density lipoprotein (VLDL) contains the greatest percentage of lipid, primarily triacylglycerol.
- Low-density lipoprotein (LDL) contains the highest percentage of cholesterol.


Dietary sources of cholesterol
Cholesterol + triacylglycerol —— VLDL
Triacylglycerol
Bile
Cholesterol
Gastrointestinal tract
HDL releases choesterol to lipoprotien carriers for delivery back to the liver
Excess cholesterol is removed from cells by the high-density lipoproteins (HDL)
Bile, produced in the liver, is stored in the gallbladder and secreted into the common bile duct that empties into the duodenum of the GI tract. Because bile contains cholesterol, cholestrol is eliminated in the feces or reabsorbed in the GI tract.

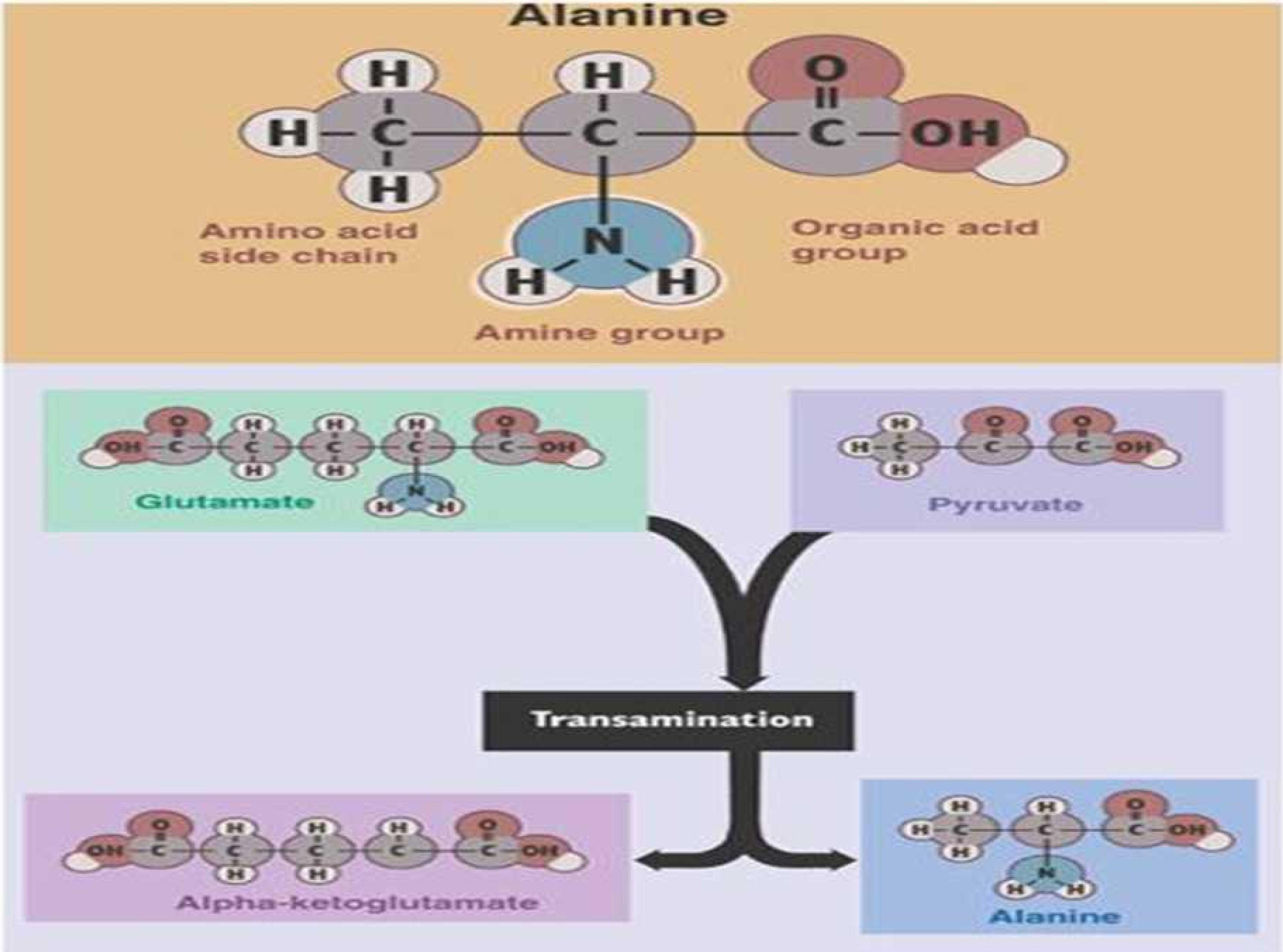

Low density lipoprotein
LDL delivers cholesterol to the cells
Cells
Plaque formed from LDL deposition on the inside walls of artery
Artery

ROLES OF LIPIDS

- Provide energy
- Protect vital organs
- Provide insulation from the cold
- Transport the fat-soluble vitamins A, D, E, and K

THE NATURE OF PROTEINS

- Formed from amino acids
  - Each of the amino acids has an amine group (NH_2) and an acid group (COOH). The remainder of the molecule is called the side chain.
  - The side chain's unique structure dictates the amino acid's particular characteristics.
  - Peptide bonds link amino acids in chains that take on diverse forms and chemical combinations.



Alanine
H
H
C
H
H
C
O
C
OH
Amino acid
side chain
N
H
H
Organic acid
group
Amine group
Glutamate
Pyruvate
Transamination
Alpha-ketoglutamate
Alanine

AMINO ACIDS

- The body requires 20 different amino acids.
- The potential for combining the 20 amino acids creates an almost infinite number of possible proteins.
- The building blocks of proteins
- The body cannot synthesize eight amino acids (nine in children and some older adults), so they must be ingested in foods; these are known as essential amino acids.
- The essential amino acids are isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine.

COMPLETE VS. INCOMPLETE

- Complete proteins contain the essential amino acids in the quantity and correct ratio to maintain nitrogen balance and allow for tissue growth and repair.
- An incomplete protein lacks one or more essential amino acid.

ROLES OF PROTEIN

- Proteins in nervous and connective tissue generally do not participate in energy metabolism.
- The amino acid alanine plays a key role in providing carbohydrate fuel via gluconeogenesis during prolonged exercise.
- During strenuous exercise of long duration, the alanine-glucose cycle accounts for up to 40-50% of the liver's glucose release.

PROTEIN METABOLISM

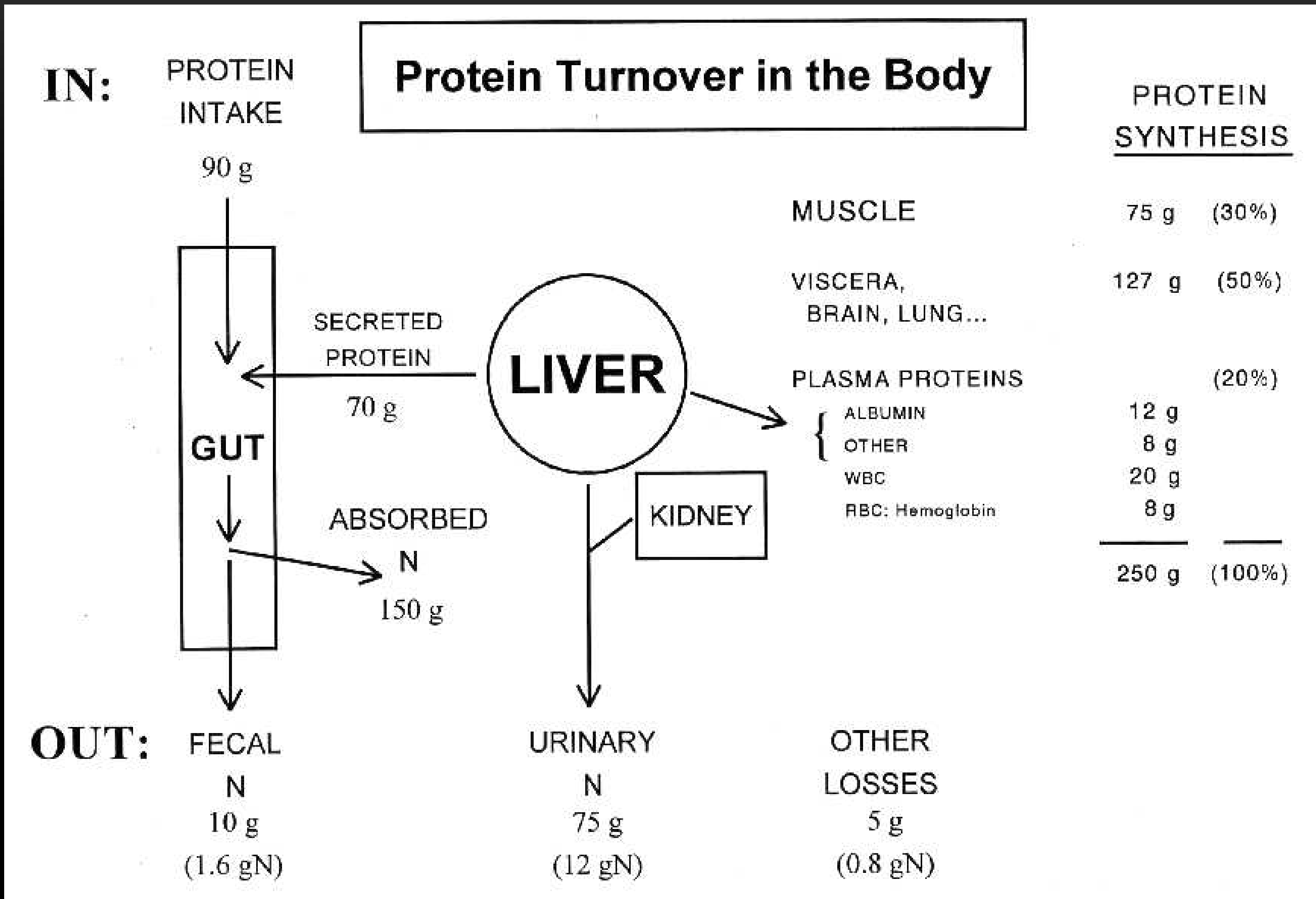
- Protein catabolism accelerates during exercise as carbohydrate reserves deplete.
- Athletes who train vigorously must maintain optimal levels of muscle and liver glycogen to minimize lean tissue loss and deterioration in performance.
- Regular exercise training enhances the liver’s capacity to synthesize glucose from the carbon skeletons of noncarbohydrate compounds.

PROTEIN NUTRITION AND METABOLISM

- In the U. S. and other industrialized nations average adult consumes ~100 g protein/day
- This accounts for about 12% of daily caloric need
- This is about 2x the RDA set by the U. S. and other countries and agencies
- Intake of protein in U. S. has remained rather constant since 1900, when it was ~10% of consumed calories
- However, proportion of animal protein has more than doubled in the intervening period

- Protein malnutrition, also called Kwashiorkor, is a common problem in less developed countries where meat, fish and other good sources of protein are scarce

- In addition to ingested protein, another ~70g/day of protein enters digestive system via gastric and intestinal juices, digestive enzymes, and cells sloughed from lining of gastrointestinal tract
- Note: life span of the gastrointestinal mucosal cell is about 3-4 days; this means that 1/4 to 1/3 of these cells are sloughed daily
- Of this daily total of ~170 g of protein entering digestive tract, about 1.6 g total N (=10 g protein) is excreted in the feces
- Remaining 160 g of protein enzymatically hydrolyzed to amino acids and small peptides


Protein Turnover in the Body
IN:
PROTEIN INTAKE
90 g
GUT
SECRETED PROTEIN
70 g
LIVER
ABSORBED N
150 g
KIDNEY
PROTEIN SYNTHESIS
MUSCLE
75 g
(30%)
VISCERA, BRAIN, LUNG...
127 g
(50%)
PLASMA PROTEINS
(20%)
ALBUMIN
12 g
OTHER
8 g
WBC
20 g
RBC: Hemoglobin
8 g
250 g
(100%)
OUT:
FECAL N
10 g
(1.6 gN)
URINARY N
75 g
(12 gN)
OTHER LOSSES
5 g
(0.8 gN)

DIETARY PROTEIN REQUIREMENT

- In 1985, WHO/FAO/UNO set daily protein requirement for adults at 0.75g/kg body wt
- This has been accepted by U. S. and Canadian governments
- Current (2002) RDA is 0.80 g/kg “ideal body weight” per day for adults
- This is 56 g/day for adult males and 46 g/day for adult females in U. S.

- Proportion of essential amino acids in “ideal” protein similar to that found in eggs and milk proteins
- In general, proteins from animals, including fish and fowl, have good proportions of essential amino acids
- Except for soybean protein, most plant proteins do not meet the ideal and usually are short of ideal in one or two of the essential amino acids

- Grains and nuts tend to be low in lysine and, sometimes, tryptophan
- Legumes tend to be deficient in sulfur amino acids, although they are important as concentrated protein foods
- As a consequence, care must be taken to combine vegetable proteins to insure combinations will supply adequate amounts of essential amino acids

- For example, black beans are deficient in sulfur amino acids, while corn meal is deficient in lysine and tryptophan
- However, in appropriate combination, black beans and corn meal constitute a complete “ideal” protein

When assessing protein content in the diet, another factor which has to be taken into account is protein digestability. In general, animal protein is more digestible than proteins of plant origin.

Table 4.4. Digestibility of Food Proteins

Food	Digestibility of Protein (%)
Eggs	97
Meats, poultry, fish	85 - 100
Milk	81
Wheat	91 - 95
Corn	90
Soybeans	90
Other legumes	73 - 85

NITROGEN BALANCE

Some important relationships to remember:

- Protein = 16% N

Therefore:

0.16 x g protein = g N or

6.25 x g N = g protein

IN CLINICAL SETTING, THE PROCEDURE INVOLVES USE OF AN EMPIRICALLY DERIVED FORMULA

N balance =

(Protein intake/6.25) – [(1.25 x urinary urea N) + 4]
(grams) (grams)

NOTE:

- 1.25 corrects for the fact that not all urinary N is in form of urea
- 4 grams added are estimate of N loss by non-urinary routes

NITROGEN BALANCE (N_{IN} - N_{OUT}) IS POSITIVE FOR:

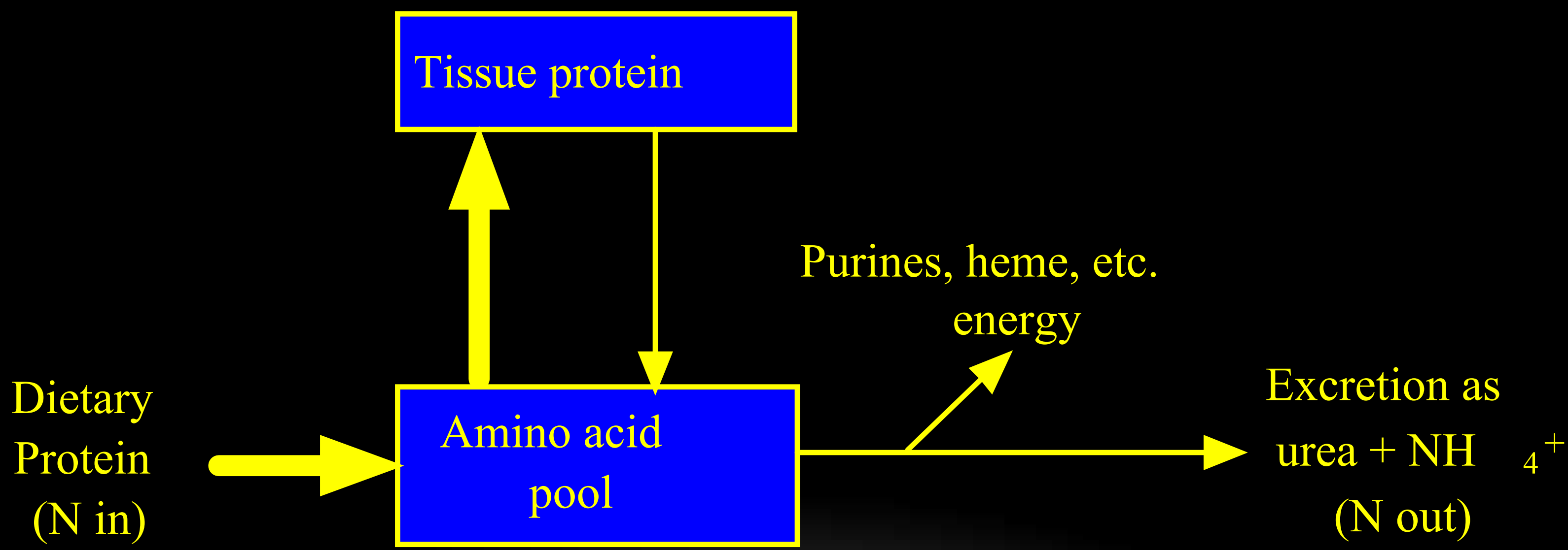
- growing infants and children
- pregnant or lactating women or body-building adult
- when there is tissue growth or replenishment such as recovering from metabolic stress or nutritional deficiency

➔ Adults receiving a minimally adequate or greater amount of protein will be at zero balance, where input = output

(a) Positive N balance

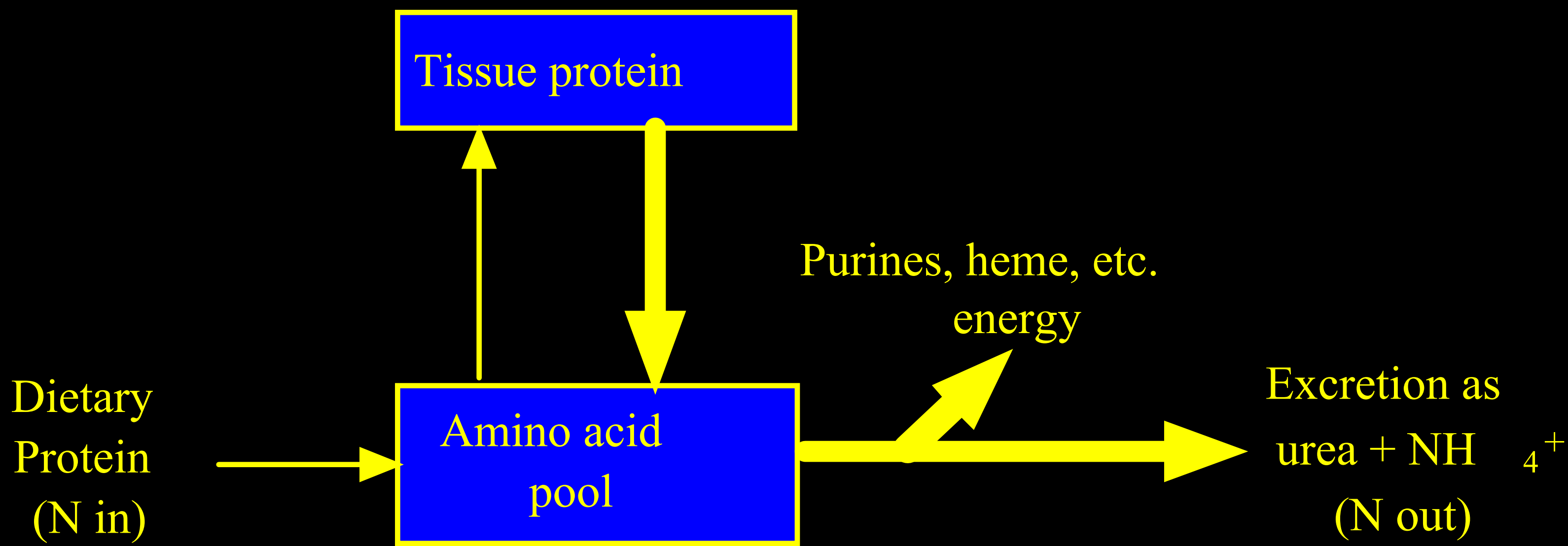
growth, lactation,

recovery from metabolic stress



Adapted from Devlin, 5/e (2002) fig. 26.1

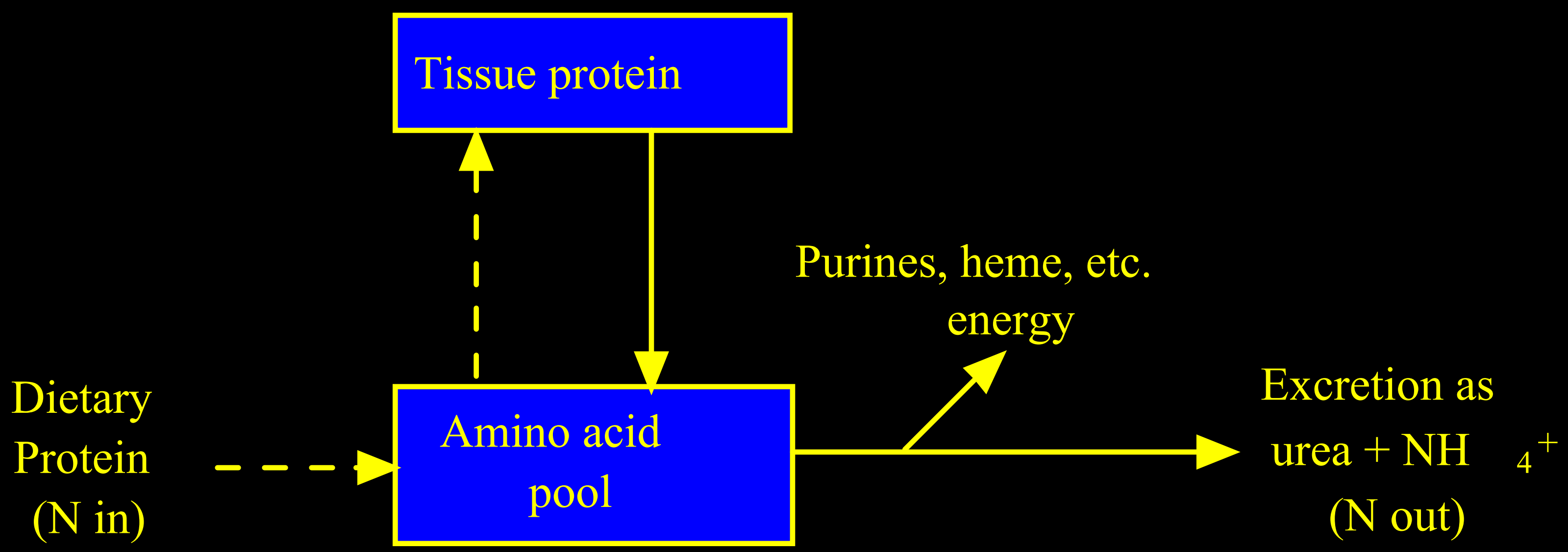
(b) Negative N balance
metabolic stress



Adapted from Devlin, 5/e (2002) fig. 26.1

(c) Negative N balance

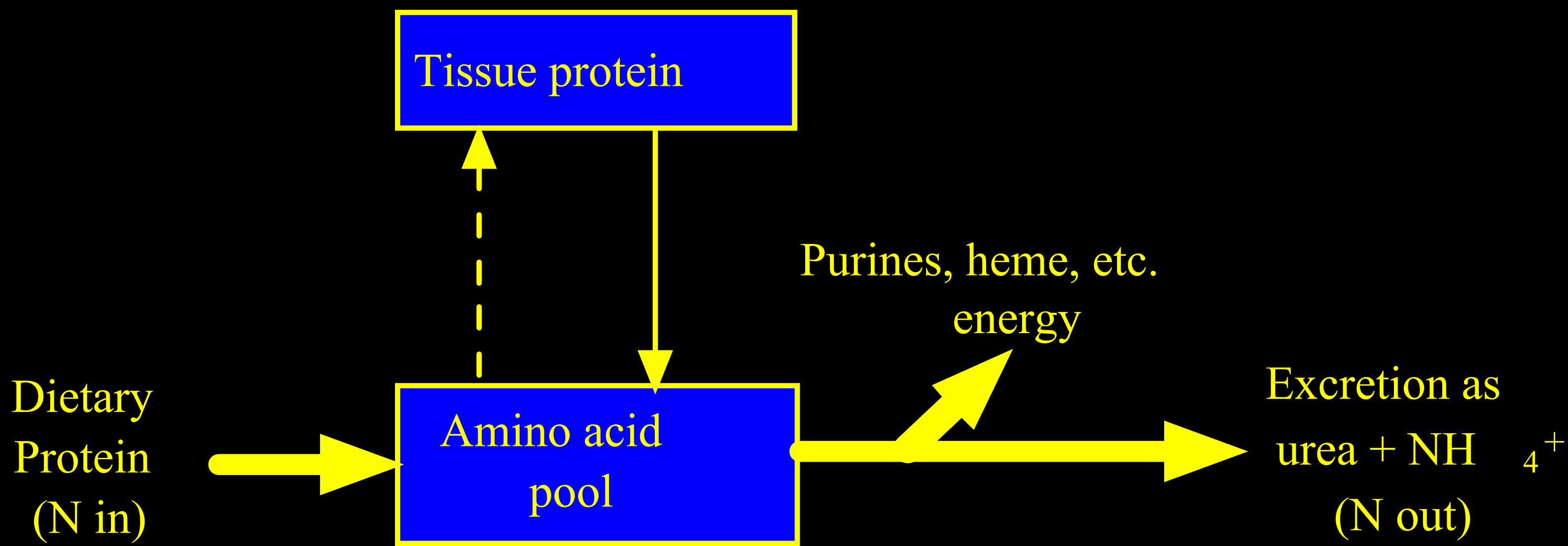
inadequate dietary protein



Adapted from Devlin, 5/e (2002) fig. 26.1

(d) Negative N balance

lack of an essential amino acid



Adapted from Devlin, 5/e (2002) fig. 26.1

NEGATIVE N BALANCE OCCURS:

- in fasting or starvation when there is no or inadequate protein intake
- in pathological conditions (burns, traumatic injury, fevers) and in severe psychological stress

- These are all conditions in which body function is diverted or activity reduced relative to the normal (bed confinement causes muscle atrophy)

  and/or

- conditions when there is abnormally high secretion of glucocortico-steroids (which causes catabolism of muscle protein)

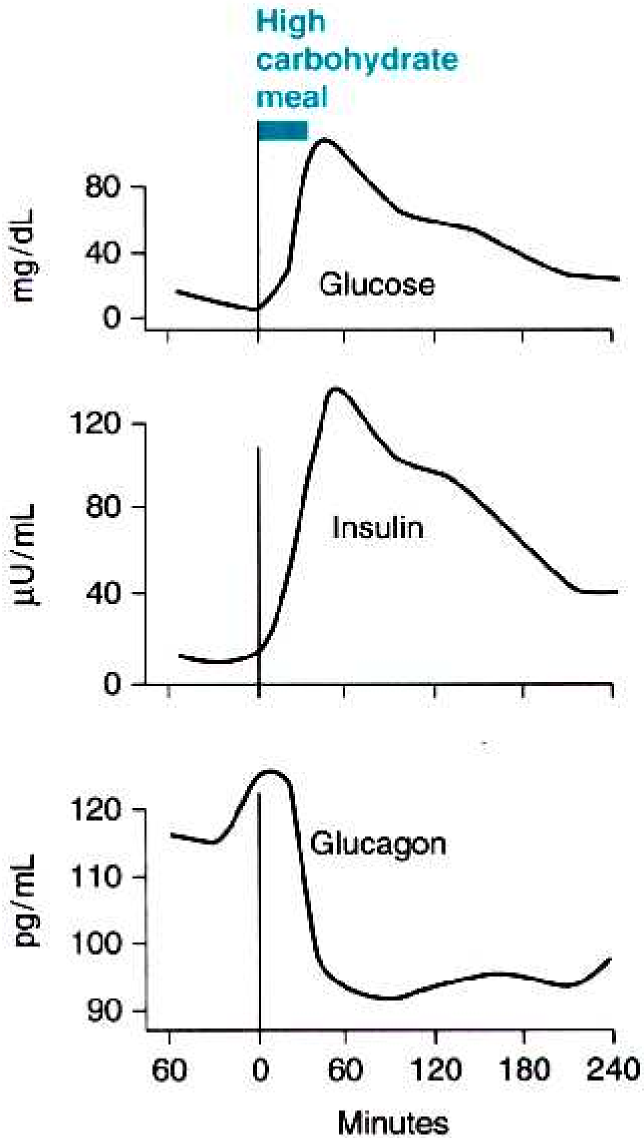


Fig. 26.8 Blood glucose, insulin, and glucagon levels after a high carbohydrate meal.

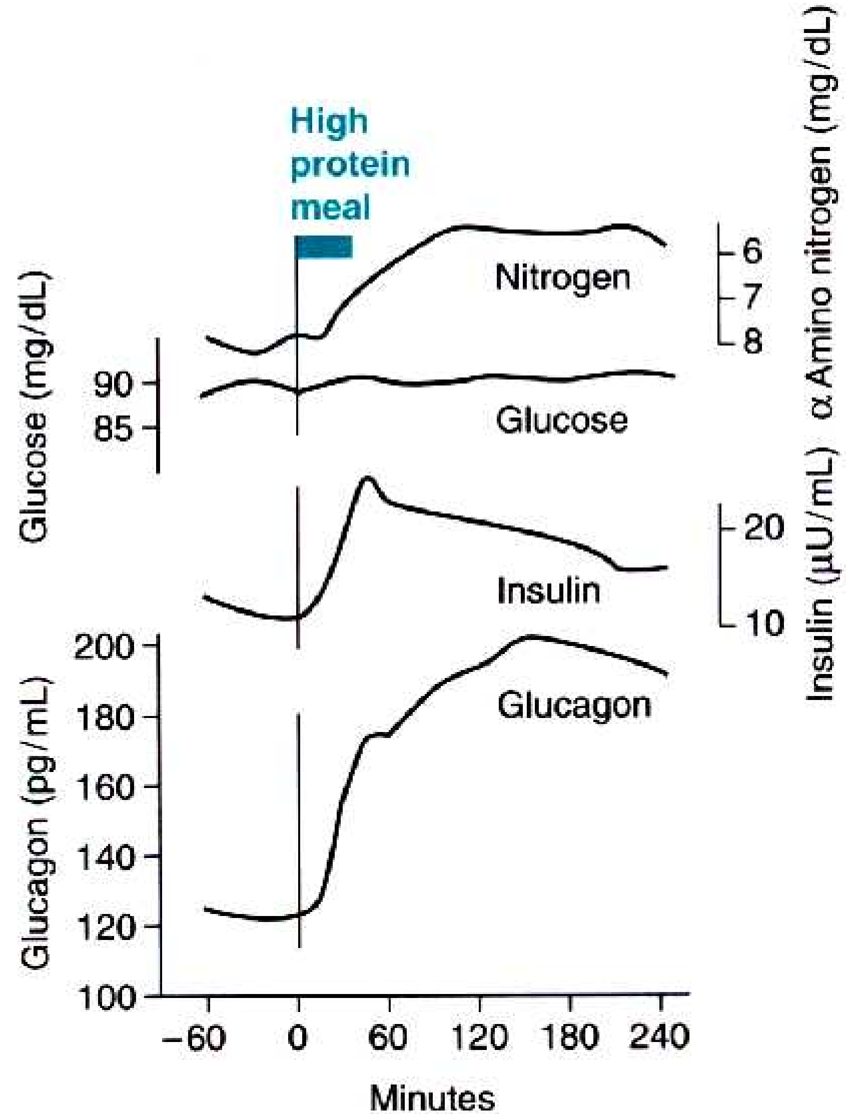


Fig. 26.12 Release of insulin and glucagon in response to a high protein meal.

ACCEPTABLE MACRONUTRIENT DISTRIBUTION RANGE (AMDR)

- AMDR just another way of stating the % of calories from a given class of macronutrient
- 2002 recs adults ≥19 years:

	% of daily calories
Carbohydrates	45 – 65%
Fats	20 - 35%
Proteins	10 - 15%

➔≤25% of total calories from "added sugar"

AMDR (CONTINUED)

- Recommendations more flexible than in past
- Ranges set so that total dietary intake would be of breadth and quality to insure intake of essential nutrients (i.e., vitamins & minerals)
- Diets very low in either carbs or fat likely to be deficient in one or more essential nutrient

AMDR (CONTINUED)

When fat intakes are low and carb intake is high:

- HDL is reduced
- ratio of plasma cholesterol:HDL increased
- plasma triacylglycerol (TAG) increased

These all consistent with increased risk of coronary heart disease (CHD; CAD)

AMDR (CONTINUED)

- When fat intakes are high, people gain weight
- Can exacerbate health of persons already susceptible to obesity, particularly risk of CHD and Type II diabetes
- High fat diets usually associated with increased intake of saturated fatty acids
- The latter, in turn, can increase LDL levels and thereby increase risk of CHD

ASSESSMENT OF NUTRIENT INTAKE

- Dietary Reference Intakes (DRIs)
  - Reference values that are quantitative of nutrient intakes to be used for planning and assessing diets for healthy people.
- Recommended Dietary Allowance(RDAs)
  - Recommended nutrient intakes that meet the needs of essentially all people of similar age and gender.
- Estimated Average Requirement (EARs)
  - Estimated nutrient intakes that meet the needs of essentially all people of similar age and gender.

ASSESSMENT OF NUTRIENT INTAKE, CONT

- Adequate Intakes (AIs)
  - Adequate intake to maintain health
- Estimated Energy Requirements (EERs)
  - Set for daily energy requirements based on defined levels of activity (Different from RDA)
- Upper levels (ULs)
  - The maximum level of daily nutrient intake that is likely to pose no risk or adverse effects

CURRENT AMERICAN DIETARY GUIDELINES

- Recommendations:
  - 55% of total kcals to come from carbohydrates
    - Sugars no more than 10%
  - 15% of total kcals to come from proteins
  - 30% or less to come from fat

MACRONUTRIENT RECOMMENDATIONS FOR CHILDREN AGES 1-3

- Fat: 30-40% of total Kcals
- Protein: 1.10 grams/kg body weight/day or approximately 13 grams of protein/day
- Carbohydrate: 130 grams/day (45-65% total Kcals/day)
- Adequate fiber: AI = 14 grams of fiber/1000 Kcal or approximately 19 grams/day

MACRONUTRIENT RECOMMENDATIONS FOR CHILDREN AGES 4-5 YEARS

- Fat: 25-35% of total Kcals
- Protein: 0.95 grams/kg body weight or approximately 19 grams/day
- Carbohydrate: 130 grams/day or about 45-65% of total energy intake, kcals
- 14 grams/1000Kcals

MACRONUTRIENT RECOMMENDATIONS FOR CHILDREN AGES 6-13 YEARS

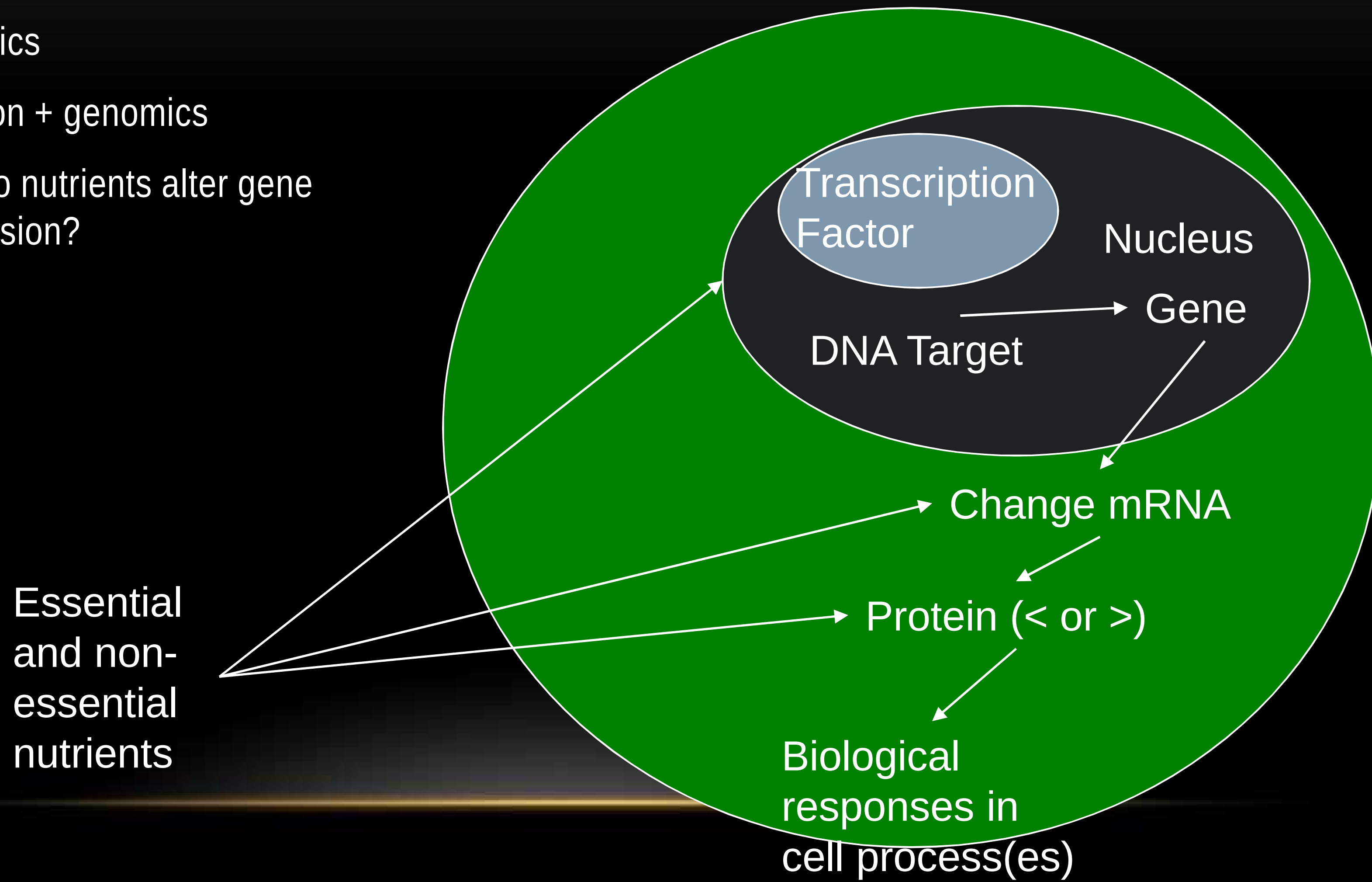
- Fat: 25-35% total energy intake, Kcals
- Protein: 0.95 grams/kg body weight/day
- Carbohydrates: 45-65% total energy intake, Kcals
- Fiber: 14 grams/1000Kcal

MACRONUTREINT RECOMMENDATIONS FOR ADOLESCENTS, AGES 14-18 YEARS

- Fat: 25-35% total energy intake, Kcals
- Protein: 0.85 grams/kg body weight
- Carbohydrate: 130 grams/day
- Fiber: 26 grams/day

NUTRIGENOMICS (NURTURE)

- Nutrigenomics
  - Nutrition + genomics
  - How do nutrients alter gene expression?



Terima kasih